Space Weather Technical Forecast

Issued on Wednesday, 20 September 2023 at 13:08 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of further G1 minor geomagnetic storms throughout, except perhaps Day 2 (21 Sep) due to HSS and CME effects. Isolated R1-R2 Minor/Moderate Radio Blackouts likely throughout. Electron Fluence likely exceeding the Active threshold by day 2 (21 Sep).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Moderate over the past 24 hours, with the peak M-class flare reaching M4.0 19/2014 UTC at 19/2014UTC. This flare associated with AR3435. Twelve active regions cover the solar disc, with three unnumbered. The aforementioned AR3435 in the northeast, is the largest and shows some minor reorganisation, with a hint of a delta spot on the southern edge. AR3438 just to the west is also relatively unchanged. This area was originally part of AR3435, but has since calved-off. AR3436 and AR3437 in the northwest and southwest respectively are the next largest regions, and AR3436 has displayed some minor changes in the intermediate spots in recent hours. The remaining regions are relatively unchanged with little activity. A CME from an M-class flare that departed the sun towards the southeast on 19 Sep. may give a glancing blow to Earth early on 23 Sep.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR/ACE at L1,remained mostly at elevated levels throughout with a mid-period peak around 650km/s and a slow and erratic decline since then with current values closer to 500 km/s. The solar wind density was near average. The IMF was at weak to moderate levels with a peak around 11nT for an hour or two at 20/0600 UTC. The north-south component (Bz) remained at weak levels, ranging from -7/+8nT. The phi angle was predominantly positive (Away from the Sun). Geomagnetic activity was Unsettled to Active (Kp3-4) peaking at G2 Moderate geomagnetic storm (Kp6), in the 19/1200-1500 UTC interval, with an overall downward trend noted.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels. GOES16 high energy (greater than 2MeV) electron flux was at Normal Background to Moderate levels with incursions through the high threshold observed from around 19/1600 UTC to 20/0000 UTC. The associated 24-hour fluence was below the Active threshold, with a rising trend and 3.32e7 integrated pfu observed at 20/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be at Low to Moderate levels, with further isolated M-class flares likely, particularly from AR3435.

Solar Wind / Geomagnetic Activity: Solar winds at elevated levels for the remainder of Day 1 (20 Sep), increasingly easing into Day 2 (21 Sep). High Speed Stream (HSS) influence is likely through the period, especially on Day 3 (22 Sep) Unsettled to Active (Kp3-4) geomagnetic activity, with a continued chance of further Minor G1 storms (Kp5). CME effects likely easing into Day 2-3 (21-22 Sep) with generally Quiet to Unsettled (Kp2-3) conditions returning. Into late Day

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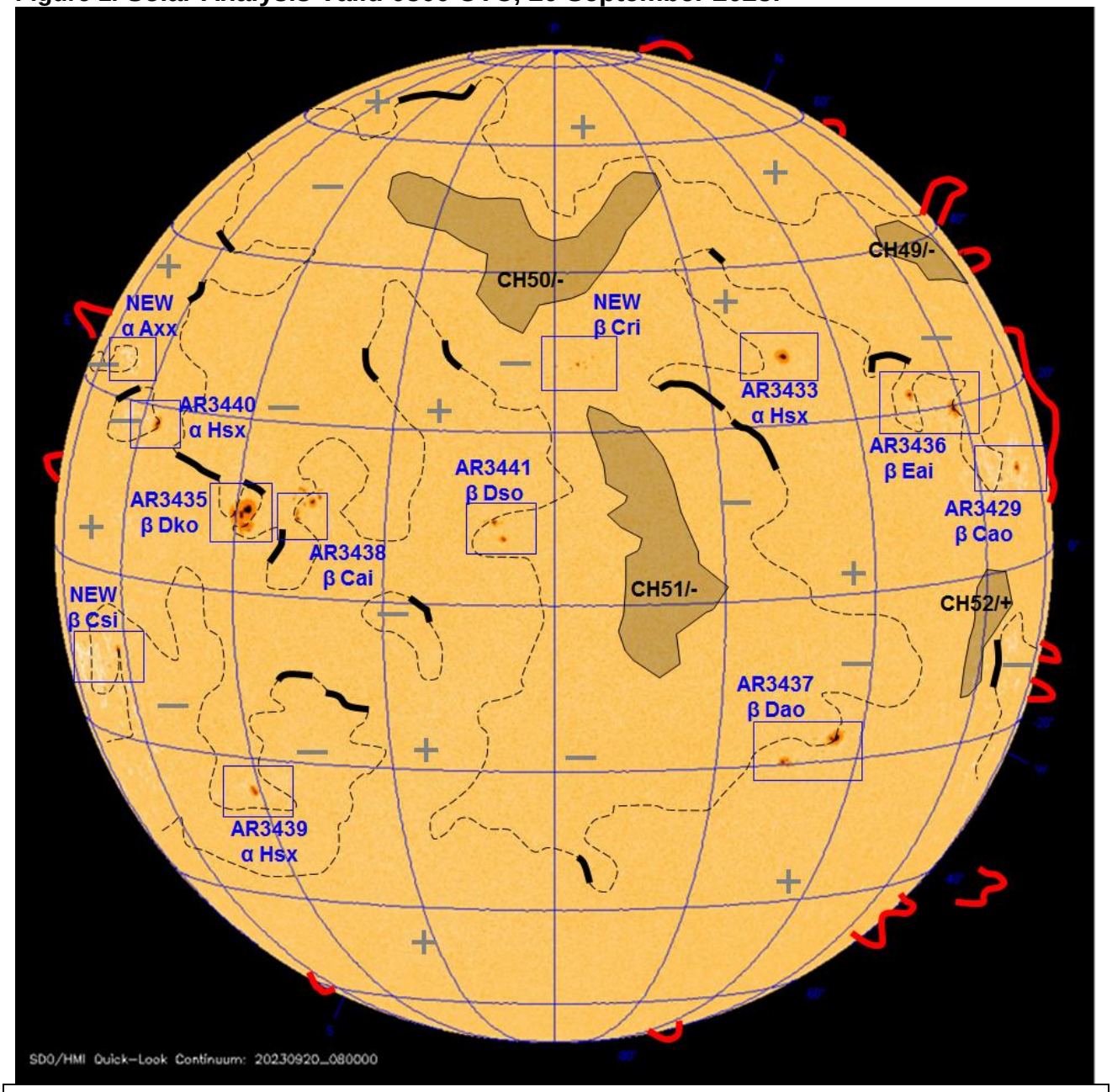
3 and Day 4 (23 Sep). Active to minor storm (Kp4-5) geomagnetic storm activity may return at times, perhaps more especially on Days 3 and 4 (22 and 23 Sep), due to a combination of a HSS around 22 Sep and a glancing blow CME on 23 Sep.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily slight chance of an enhancement should any larger flares occur, or perhaps early in the period in association with CME arrival. High energy (greater than 2 MeV) electron flux is likely to be mostly at moderate to high levels Overall, the 24-hour fluence is now likely to rise above the Active threshold by Day 2 (21 Sep), and potentially remain elevated though with reducing confidence later in the period.

Figure 1. Solar Analysis Valid 0800 UTC, 20 September 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

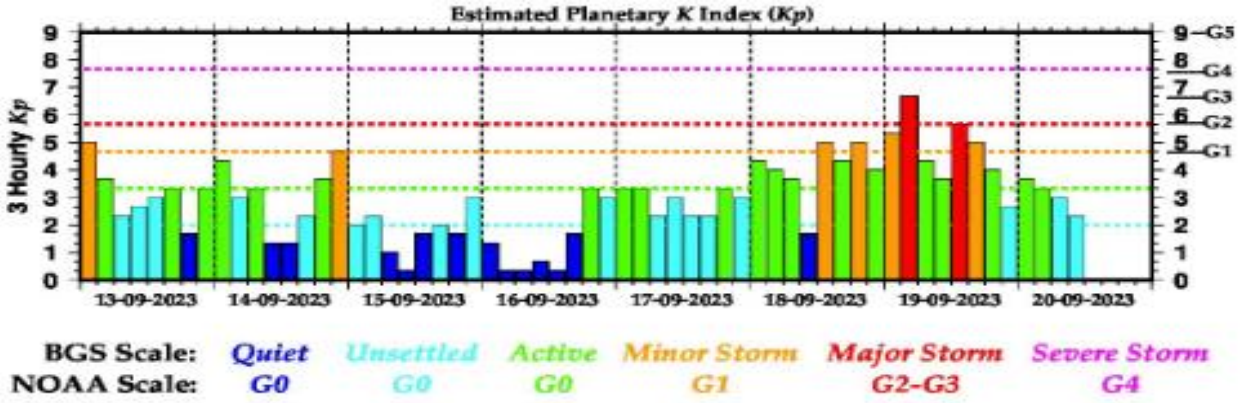
It now appears that the recent CME influencing the near Earth environment is associated with the large filament lift off which occurred early on the UTC day of 16 Sep. This CME produced an asymmetric halo seen clearly in LASCO-C2 and C3 coronagraph imagery. Modelling suggested an Earth directed component with a later arrival than reality. Analysis was complex with reduced forecast confidence and it now looks likely that we saw an earlier than expected arrival. CME effects look to be waning. The background solar wind conditions have lower than average forecast confidence through the period, with conditions complicated by the potential influence from one or more coronal holes. The increasingly faded CH52/+ seeing any potential influence during Day 1 easing into the period. The centre disk CH51/- then increasingly likely to influence conditions into Days 3-4 (22-23 Sep) though persistence data suggest that the current ENLIL signal for Elevated wind speeds looks slightly excessive. A CME from an M-class flare that departed the sun towards the southeast on 19 Sep. has been analysed and modelling from Met Office ENLIL shows that it may give a glancing blow to Earth late o22 Sep or early on 23 Sep. Current CME effects are expected to continue easing Day 1 (20 Sep). Generally Active geomagnetic activity at first, with a continued chance of further G1-G2 Minor to Moderate storms. Current CME effects likely easing into Day 2-3 (21-22 Sep) with generally Quiet to Unsettled (Kp2-3) conditions returning. Into late Day 3 and Day 4 (23 Sep). Active to minor storm (Kp4-5) geomagnetic storm activity may return at times, perhaps more especially on Days 3 and 4 (22 and 23 Sep), due to a combination of a HSS around 22 Sep and a glancing blow CME on 23 Sep

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	30	10	40	30
Strong	G3	No	1	1	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Figure 2: BGS geomagnetic activity over the past 24 hours, with generall downward trend.



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Radio Blackouts - X-Ray Flares:

The largest and most active region on the disk is AR3435 (Dko/Beta) in the northeast, with the M4.0 flare yestetday evening indicating an escalation of activity. Continuing magnetic complexity visible with a north-south magnetic alignment likely aiding shear instability. In total on the visible disc twelve active regions are evident, with three unnumbered. AR3435 in the northeast, is the largest and shows some minor reorganisation, with a hint of a delta spot on the southern edge. AR3438 (Cai/Beta) just to the west is also relatively unchanged. This area was originally part of AR3435, but has since calved-off. AR3436 (Eai/Beta) and AR3437 (Dao/Beta) in the northwest and southwest respectively are the next largest regions, and AR3436 has displayed some minor changes in the intermediate spots in recent hours. The remaining regions are relatively unchanged with little activity. Solar activity is expected to remain at Low to Moderate levels. There is a continued chance of further M-class flares, with the greatest risk continuing to come from AR3435 in the northeast, and perhaps also from Ar3436 and AR3438.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: X-ray flux activity at GEO as observed by GOES, with M-class flare observed in past 24 hours.

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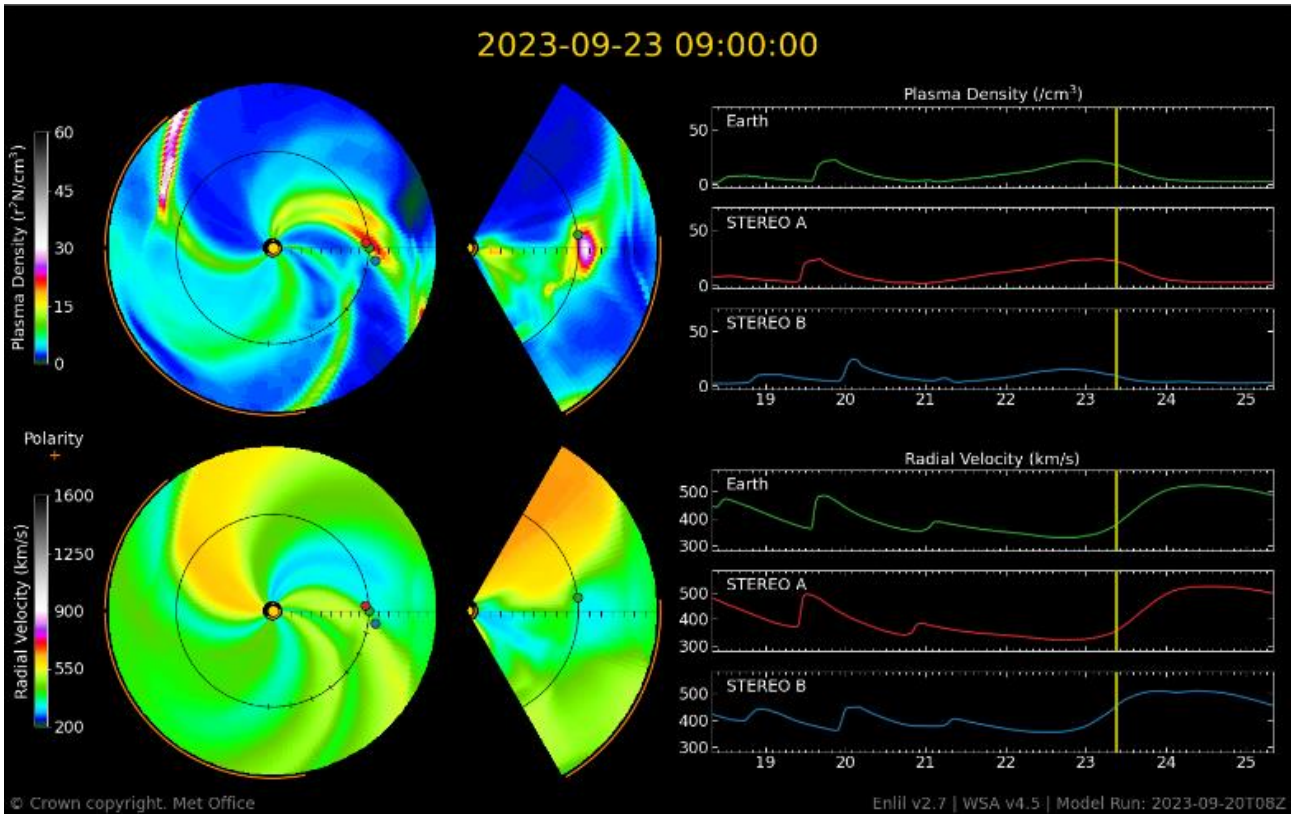
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at Background levels, but with a daily slight chance of flux levels rising in response to any significant flaring.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Met Office ENLIL model showing possible CME glancing blow with Earth early on 23 Sep. as well as probable HSS arrival around 24hrs prior to this.



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High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2MeV) electron flux levels are likely to breach the 1000pfu high threshold. An uncertain forecast, with CME arrivals and continued elevated solar winds likely to have seen a build up of change within the belts and any easing of solar winds and reduction of geomagnetic activity expected to see flux levels increasingly rise above the High threshold. Some reduction likely in the near term however, both diurnally but also given the potential for further geomagnetic activity. The 24-hour fluence is currently below the Active threshold but on a rising trend, with current MOSWOC REFM output forecast providing reasonable guidance, with a much increased, and now likely, risk of breaching the active threshold by Day 2 (21 Sep). Forecast remains lower confidence however given uncertainties in the near term.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	60	70	80	80
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	5	5

Figure 5: High energy electron flux at GEO and Met Office REFM output, showing upward trend in activity.

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